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INNOVATIVE TECHNOLOGY
Summary Report

Fog and Strip Decontamination Technology for use in D&D Environments

Deactivation and Decommissioning Focus Area

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INNOVATIVE TECHNOLOGY
Summary Report

Fog and Strip Decontamination Technology for use in D&D Environments

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Deactivation and Decommissioning Focus Area

Demonstrated at
Nuclear Fuel Services
Erwin, Tennessee

Purpose of this document

Innovative Technology Summary Reports (ITSR) are designed to provide potential users with the information they need to quickly determine whether a technology would apply to a particular environmental management problem. They are also designed for readers who may recommend that a technology be considered by prospective users.

Each report describes a technology, system, or process that has been developed and tested with funding from DOE's Office of Science and Technology (OST). A report presents the full range of problems that a technology, system, or process will address and its advantages to the DOE cleanup in terms of system performance, cost, and cleanup effectiveness. Most reports include comparisons to baseline technologies as well as other competing technologies. Information about commercial availability and technology readiness for implementation is also included. Innovative Technology Summary Reports are intended to provide summary information. References for more detailed information are provided in an appendix.

Efforts have been made to provide key data describing the performance, cost, and regulatory acceptance of the technology. If this information was not available at the time of publication, the omission is noted.

All published Innovative Technology Summary Reports are available on the OST Web site at "http://apps.em.doe.gov/ost/istrall.html".

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SECTION 1
SUMMARY

Technology Summary

The Integrating Contractor Team of the Los Alamos National Laboratory (LANL) Large Scale Demonstration and Deployment Project (LSDDP) demonstrated the fog and strip technology implemented by Master Lee Decontamination Systems (MLDS) as a potential decontamination technology for application in the LANL Decontamination and Volume Reduction System (DVRS) for plutonium contaminated structures. The MLDS fog and strip technology involves fogging a confined space to reduce airborne contamination levels, followed by applying a strippable coating to the walls of the space to encapsulate contaminants.

Problem

Many enclosed spaces, such as gloveboxes, enclosures, and hot cells, within the Department of Energy (DOE) complex contain fixed, removable and airborne radioactive contamination. One approach to decontaminating enclosed spaces is by application of a strippable coating to the contaminated surfaces by personnel dressed in appropriate personal protective equipment (PPE). After the strippable coating has cured, it is then peeled from the surfaces and discarded along with the contaminants. This decontamination approach has several disadvantages for personnel: 1) high radiation exposure, 2) additional time wearing PPE, which is especially cumbersome when wearing a supplied air suit. To address both issues, continuous improvements for workers and in environmental protection are encouraged whenever possible per ALARA principles.

How It Works

The MLDS fog and strip decontamination technology is comprised of two parts: 1) injection of an air-transported glycerin (and/or saccharide) fog called Capture Coating™ into a room or enclosure to reduce airborne contaminants followed by 2) application of a strippable coating, in this case Insta-Cote™, to fix loose contaminants. Removal of the strippable coating decontaminates the surface and produces a solid waste. It is important to note that both parts of this technology may be used separately; the technology considered in this demonstration is the combination of both parts to achieve one goal. The combination of fogging followed by stripping is superior to strippable coating decontamination alone. The advantages of the fog and strip technology are reduction of airborne contaminants prior to entry by personnel, the absence of liquid wastes, and the potential for a large volume reduction of contaminants.

Potential Markets

The fog and strip decontamination technology is well suited to any decontamination project where high airborne contamination levels are present in enclosed areas. Used alone, the fog can be used to reduce airborne contamination prior to workers entering an enclosed area. This improves worker safety, since less time is spent within the area. The Insta-Cote™ strippable coating requires very little time to dry and can be walked on soon after it is applied. This also reduces the time spent in the area. As a strippable coating, Insta-Cote™ has been shown to be effective for removing radionuclides, dirt, PCBs, asbestos particles and loose paint from surfaces. Typical applications involve bare and painted concrete, wood, carbon steel, stainless steel, plastic, and insulation. Insta-Cote™ can also be used alone as a coating to prevent surfaces from becoming contaminated. It can also be left intact to fix contamination for later decontamination and decommissioning (D&D) or for waste packaging activities.

Advantages over baseline

The baseline technology for this fog and strip decontamination demonstration is Bartlett Stripcoat TLC™. Bartlett Stripcoat TLC™ is applied with a spray gun and requires approximately 9 hours to dry. The innovative fog and strip technology demonstrated here offers an advantage over the baseline technology in that it is expected to provide better decontamination and the strippable coating is applied in an

environment with a much lower air contaminant concentration. The use of the demonstrated technology using Insta-Cote™ allows workers to enter the area under safer conditions.

Demonstration Summary

This report covers the period of July 31 – August 5, 2001, when the fog and strip technology was demonstrated at the Nuclear Fuel Services (NFS) facility in Ervin, TN as part of the LSDDP. The purpose of the demonstration was to evaluate the effectiveness, efficiency, and cost of implementing the innovative fog and strip technology as an alternative to the baseline. The baseline technology was Bartlett Stripcoat TLC™, a common strippable coating. Radiological surveys, for transferable contamination, as well as air concentration surveys were taken both before and after the demonstration. The purpose of these surveys was to determine the level of decontamination achieved by the baseline and fog and strip technologies. Labor hours required for mobilization, application, and demobilization were also recorded.

Demonstration Site Description

A PermaCon enclosure was used for this demonstration to process and package contaminated gloveboxes. Consequently, the inner surfaces of this PermaCon are contaminated with plutonium and associated transuranic elements. This PermaCon is composed of two areas, a decontamination (Decon) area, and a chemical area. The total internal surface area is approximately 1,228 ft^2. The baseline technology was demonstrated on ten percent of the surface area, while the innovative technology was applied to the entire surface area. The PermaCon has aluminum, stainless steel, and Plexiglas surfaces.

Key Results

The fog and strip decontamination technology was successfully demonstrated at NFS with the following key results:

- The fog and strip technology reduced the airborne concentration from 443 to less than 0.5 Derived Air Concentration (DAC)

- The fog and strip technology successfully removed transferable (surface) contamination from aluminum, stainless steel, and Plexiglas, with average decontamination of 91.36%, 94.30% and 54.5% respectively. The improvement over the baseline was 1.4% for aluminum surfaces, 6.7% for stainless steel surfaces and 14% for Plexiglas surfaces.

- No liquid waste was generated during the demonstration.

Regulatory Considerations

There are no regulatory considerations to use the fog and strip decontamination technology.

Commercial Availability

The fog and strip decontamination technology is fully developed and commercially available from MLDS.

Future Plans

The fog and strip decontamination technology will be used on future D&D projects at LANL, both as a decontamination technology and as a fixative.

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Other

All published Innovative Technology Summary Reports are available on the OST Web site at "http://apps.em.doe.gov/ost/istrall.html". The Technology Management System (TMS), also available through the OST Web site, provides information about OST programs, technologies, and problems. The OST/TMS ID for the Fog and Strip Decontamination Technology is 3143.

SECTION 2
TECHNOLOGY DESCRIPTION

Overall Process Definition

The objective of the demonstration was to quantitatively evaluate the effectiveness of a fogging and stripping system in the reduction of airborne radioactively contaminated particulates during the decontamination of the interior of a small structure and the subsequent decontamination using strippable coatings. In particular, the objective was to evaluate the combination on plutonium contaminated surfaces, as would be experienced in a LANL DVRS application.

The fog and strip decontamination technology involves two parts: 1) injection of an air-transported glycerin (and/or saccharide) fog into a room or enclosure to reduce airborne contaminants, followed by 2) applying a strippable coating to fix and/or remove loose surface contamination. In this demonstration, the selected fog was Capture Coating™ and the strippable coating was Insta-Cote™, both supplied by Master-Lee Decontamination Services (MLDS). The labor, equipment and materials for these technologies were provided by MLDS as a contracted service.

Capture Coating™ was produced within an aerosol generator, then introduced into an enclosure in a fine aerosol fog that encapsulated airborne contaminants and coalesced onto the surfaces as a fine coating. This coating provided only a short-term fixative for plutonium surface contamination.

The Insta-Cote™ mixture is an adherent paint-like coating that was applied over the fog film to provide a long-term fixative for plutonium surface contamination. The Insta-Cote™ mixture dries quickly and can be walked on soon after it is applied. Removal of this coating involved stripping or pulling it away from the surface which decontaminated the surface and resulted in a solid waste. To facilitate its removal, the coating was scored into large sections with a sharp knife.

The baseline approach for removing surface contamination involved entry into the contaminated area wearing appropriate PPE, followed by applying Bartlett Stripcoat TLC™ strippable coating. Stripcoat TLC™ is a water-based coating containing ammonia. When applied over contaminated surfaces, the material chemically locks the contaminant into a polymer matrix. For the baseline approach, Stripcoat TLC™ was applied with a spray gun and allowed to dry for at least nine hours before it was removed. Bartlett Stripcoat TLC™ can also be rolled, brushed, or poured onto the surface in the same manner as paint. However, the vendor recommends spray application for decontamination purposes.

Stripcoat TLC™ is yellow and has a thick consistency. Removal of the film decontaminates the surface and produces a solid waste.

System Operation

Fog and Strip Technology

MLDS operated the fogging and the Insta-Cote™ application machine from a truck parked outside the area. The truck contained an aerosol generator, Insta-Cote™ application equipment and drums of decontamination chemicals. The maximum distance from the truck to the application point is approximately 300 feet. The machines and chemical drums can be moved closer to the application area if needed.

The room was first fogged with a fine aerosol created by an aerosol generator that uses ultrasonic waves to produce very small droplets. Note that the ventilation system flow was reduced to the minimum acceptable by NFS safety standards prior to initiation of the fogging. The fog was then blown into the PermaCon through a flexible duct. The fogging process was continued until beads were visible on windows within the area. The aerosol was allowed to stand overnight to continue coalescing on the PermaCon walls and equipment surfaces.

A 1/8 to 1/4-inch layer of the Insta-Cote™ was then applied using an application machine and spray gun to fix the contamination in place. Insta-Cote™ can be removed by scoring the desired area using a utility knife and then pulling it from the surface. A considerable amount of effort was used to remove the Insta-Cote™ from the surfaces.

Baseline Technology

In the baseline technology, no attempt was made to reduce airborne contamination prior to application of the strippable coating. NFS technicians applied the Bartlett Stripcoat TLC™ to approximately 10% of the internal surfaces using a standard spray gun.

Table 1 contains the equipment specifications and operational parameters for Bartlett Stripcoat TLC™ vs. fogging followed by Insta-Cote™.

Table 1. Equipment Specifications and Operational Parameters for Decontamination Technologies

	Bartlett Stripcoat TLC™	Capture Coat™ Fog	Insta-Cote™
Equipment Specifications and Operational Requirements			
Surface preparation	None required	None required	None required
Application conditions Normal Minimum Maximum	 70F(21C) at 50% RH 40F (4C) at 10% RH 90F (32C) at 85% RH		
Recommended thickness	20-30 mils (dry)	N/A	Unknown
Application equipment used for the demonstration	Spray applicator	MLDS fog generator	MLDS Insta-Cote™ Applicator
Application Instructions	Hold spray gun at a 45 angle to surface and approximately 10-12 in. from surface. Move spray gun slowly (10 – 15 in./sec) across area	MLDS operated	MLDS operated
Theoretical coverage	26 ft^2/gal		8.5 ft^2/gal
Number of gallons of used for the demonstration	1	2	50
Manpower Skills and Training Requirements			
Work crew	Two to three full-time NFS mechanics	Two to three contr. (MLDS) mechanics + NFS support personnel as required	Two to three contr. (MLDS) mechanics + NFS support personnel as required
Specialized skills	None required	None required – by contractor	None required – by contractor
Training	The vendor-supplied training to the NFS mechanics on the operation of the spray applicator	Contractor-supplied training to the mechanics on the operation of the fogger.	Contractor-supplied training to the mechanics for application, plus adherence to requirements driven by MSDS-stated chemical properties.
Potential Operational Concerns			
Operating	During spraying, the gun tip can get clogged and would have to be taken apart and cleaned. The use of a reversible tip minimizes this concern.	Difficult to measure endpoint for fogging: how long to apply fog to enclosure	During spraying, the gun tip can get clogged and would have to be taken apart and cleaned. The use of a reversible tip minimizes this concern.
Safety/health	Airline respirators are recommended by the vendor to prevent inhalation of over-spray. Full face respirators were required by NFS due to possible airborne contamination while spraying.	Use of fog reduces visibility inside the enclosure. Electrical hazards present in the use of compressor and power tools.	Permissible Exposure Limit (PEL) is 0.02 ppm. If exposures exceed this limit, use supplied air respiratory protection. Skin contact will result in dermal irritation.
Environmental	Potential release of airborne radionuclides during strippable coating application.	Potential release of airborne radionuclides if enclosure is breached.	Oxidation of product upon exposure to air may result in release of cyanide gas.

SECTION 3
PERFORMANCE

Demonstration Plan

Demonstration Site Description

The demonstration of the fog and strip decontamination technology was conducted according to the approved LANL test plan, which contains a description of the prerequisites, test procedures and post-test decontamination and demobilization requirements (Reference 1). Figures 1 and 2 depict the PermaCon.

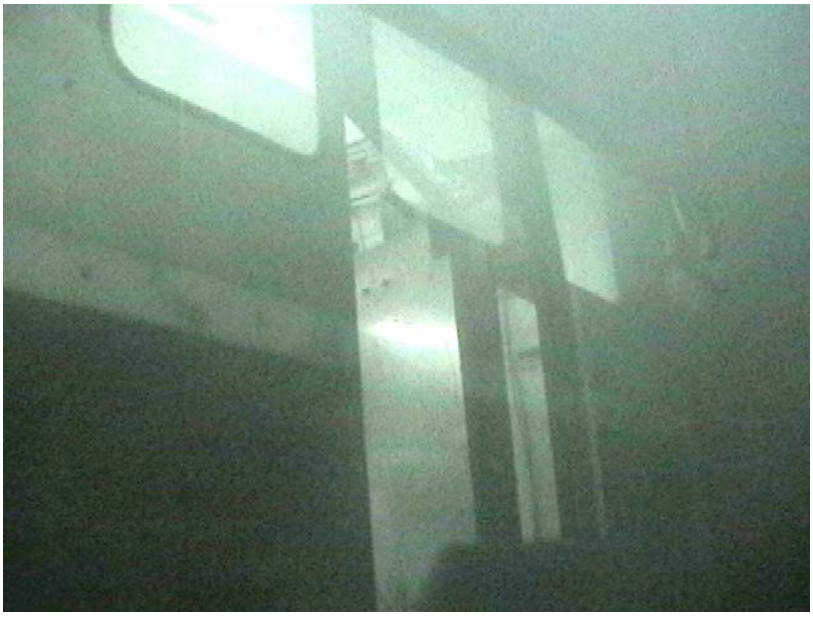

Figure 1 – Permacon after fogging

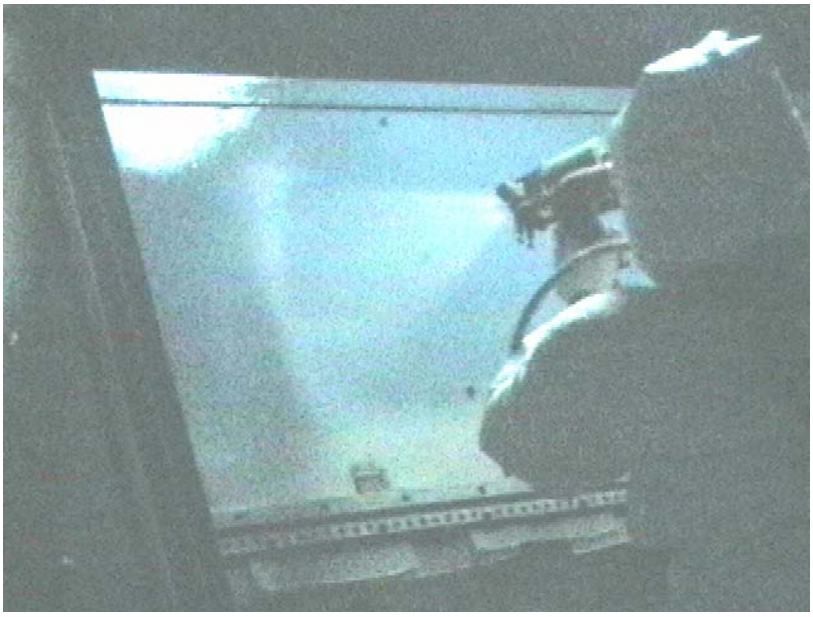

Figure 2 – Application of Insta-Coat™ in PermaCon

Table 2 lists dimensions and surface areas of the PermaCon enclosure.

Table 2 – PermaCon Dimensions and Materials

	Dimensions	Total (ft^2)	Aluminum (ft^2)	Stainless Steel (ft^2)	Plexiglas (ft^2)
Decon Cell	14' x 14' x 9'	746		746	
Wet Processing Area	9' x 4 ' x 10'	242	152		90
NDA Station	6' x 10' x 6'	300	300		
Total	2,484 ft^3	1,288	452	746	90

The baseline technology was applied to 128 ft^2 (10% of total) while the Fog and Strip technology was applied to the entire interior surface.

The PermaCon includes double doors, a shear bailer, and overhead cranes that are not included in the surface areas listed in Table 2.

Demonstration Objectives

The overall test objectives of the fog and strip decontamination demonstration were to determine the following, and to compare the results for both the baseline and alternative technologies:

- Airborne contamination removal efficiency
- Decontamination performance
- Waste generation volume
- Decontamination time
- Mobilization time
- Demobilization time
- Personnel requirements

Results

Airborne Contamination Removal Efficiency

Pre- and post-demonstration airborne samples were obtained through an installed sampling system consisting of a low volume pump, filter chamber, calibrated flow meter, and associated tubing and piping. Flow rates of 40 liters/minute were used, which are consistent with NFS sampling standards. In addition, a lapel sample was obtained during the Insta-Cote™ application process. This sample was obtained by attaching a sampler external to the operator's PPE. Each sample was counted on a Protean Instrument Corp. WPC-9550 at the intervals listed in Table 3. The samples were counted after a period of 6 days to allow for decay of short-lived isotopes. Results are listed below in Table 3.

Table 3 – Air Contamination Levels during Fog and Strip Decontamination Demonstration

TYPE	ACTIVITY (UC/ml)	DAC	COMMENTS
Pre-Demonstration	1.36E-09	454.2	Ventilation at Max
Post-Fog	1.21E-12	0.4	Ventilation at Min.
Post-Fog	-3.56E-13	0.00	Ventilation at Max.
During Insta-Cote™ Application	4.14E-09	1378.40 (DAC-HRS)	Ventilation at Max-Lapel Sample
Post-Insta-Cote™	5.02E-13	0.17	Ventilation at Max-During Stripping Process
Post-Insta-Cote™	7.71E-13	0.26	Ventilation at Max – After Final Coating

Decontamination Performance

Prior to the demonstration, contamination smears were taken in the PermaCon on varying surfaces, including aluminum, Plexiglas, and stainless steel. Two sets of smears were taken on each type of surface to allow a comparison of results between the baseline technology and the fog and strip process. After each type of coating was applied and removed, a second set of smears was taken adjacent to the initial smears on each surface. Smears were taken in the PermaCon during the Insta-Cote™ stripping process, and again after the entire process was completed. All smears were taken across an area of 100 cm^2 using moderate pressure. To eliminate variations due to worker technique, the same technician collected all test smear samples. Results are summarized in Table 4.

The fog and strip process successfully demonstrated its ability to remove surface contamination from metal and aluminum surfaces safely and effectively. Table 4 summarizes the decontamination results from the demonstration.

Table 4 - MLDS Fog and Strip Decontamination Results

ALUMINUM SURFACE				
INITIAL SMEARS	POST-BASELINE		POST-INSTA-COTE™	
(dpm/100 cm^2)	(dpm/100 cm^2)	DF*/(%removal)	(dpm/100 cm^2)	DF*/(%removal)
706,000	67,000	10.5/(90.5%)		
227,000	30,000	7.6/(86.8%)		
853,000	58,000	14.7/(93.2%)		
259,000			22,000	11.8/(91.5%)
350,000			51,000	6.9/(85.5%)
498,000			15,000	34.4/(97.1%)
Average		10.9/(90.2%)		17.7/(91.4%)

PLEXIGLASS SURFACE				
INITIAL SMEARS	POST-BASELINE		POST-INSTA-COTE™	
(dpm/100 cm^2)	(dpm/100 cm^2)	DF*/(%removal)	(dpm/100 cm^2)	DF*/(%removal)
1,179,000	659,000	1.8/(44.1%)		
3,081,000	439,000	7.0/(85.7%)		
1,780,000	1,552,000	1.1/(12.8%)		
1,121,000			294,000	3.8/(73.8%)
1,736,000			1,558,000	1.1/(10.2%)
2,285,000			468,000	4.9/(79.5%)
Average		3.3/(47.5%)		3.3/(54.5%)

Table 4 - MLDS Fog and Strip Decontamination Results (Continued)

STAINLESS STEEL SURFACE				
INITIAL SMEARS	POST-BASELINE		POST-INSTA-COTE™	
(dpm/100 cm^2)	(dpm/100 cm^2)	DF*/(% removal)	(dpm/100 cm^2)	DF*/(% removal)
3,676,000	405,000	9.1/(89.0%)		
3,466,000	273,000	12.7/(92.1%)		
1,629,000	260,000	6.3/(84.1%)		
3,853,000			30,000	130.5/(99.2%)
3,007,000			36,000	84.4/(98.8%)
727,000			110,000	6.6/(84.9%)
Average		9.4/(88.40%)		73.8/(94.30%)

* Decontamination Factor (DF) is calculated by dividing the initial count by the final count.

Demonstration Timeline

Baseline Technology:
The first day of the demonstration included collecting air samples, collecting surface smears, setting up the Stripcoat TLC™ application equipment, worker entry into the PermaCon, spraying surfaces (10% of the area), worker exit, and clean-up of equipment.

Innovative Technology:
The second day of the demonstration included mobilization of MLDS equipment, modification of the PermaCon to accommodate the equipment and initiation of fogging. The MLDS truck was located approximately 50 ft. from the PermaCon, where it remained for the duration of the demonstration. The aerosol generator was moved to within 100 ft of the work area, allowed to warm up, tested, then connected to the PermaCon through a 12-inch flexible hose. The PermaCon modifications included reducing airflow by lowering the system differential pressure from 1.5 to 0.005 inches of water column, modifying the inlet HEPA filter housing to accommodate the fog hose, removing the roughing filters, and installing scaffolding within the PermaCon. Fogging was initiated and allowed to proceed overnight.

The third day of the demonstration included application of Insta-Cote™ to the PermaCon surfaces. MLDS technicians set up a spray applicator and associated hose connections. They also connected the power and air supplies and tested all equipment before entering the area. The spray applicator and chemical drums remained in the truck during the demonstration. The hose connecting the Insta-Cote™ applicator and spray gun was covered by a plastic sleeve to prevent contamination. The hose ran through the airlock doors on the PermaCon.

The fourth day was devoted to removing the Insta-Cote™ from 10% of the total surface area, plus several specific areas, then collecting surface smear samples of the areas from which the Insta-Cote™ was peeled.

The fifth day was devoted to demobilization of MLDS equipment. These activities included cleaning, decontamination, liquid waste handling and removal of PPE as well as removal of equipment from the work site.

Specific parameters regarding waste generation, decontamination time, mobilization time, demobilization time and personnel requirements are listed in Table 5.

TABLE 5 – Fog and Strip Demonstration Specifics

	Bartlett Stripcoat TLC™ (baseline)	Fogging	Insta-Cote™
Total area included in demonstration	128 square feet	Entire PermaCon (1,288 ft^2)	Entire PermaCon (1,288 ft2)
Work surfaces	Aluminum, Stainless Steel, Plexiglas		Aluminum, Stainless Steel, Plexiglas
Mobilization			
Required personnel	2 Radiation Technicians 2 Standby operators	2 MLDS technicians 2 technicians to connect hose 2 engineers to alter HVAC	2 MLDS technicians to set up Insta-Cote™ application equipment, and sleeve hose.
Equipment preparation time	22 minutes	1 hour to move fog generator into area and to heat up fog solution.	4 hours for Insta-Cote™ heat up
Demonstration			
Required personnel	2 workers 2 radiological control technicians	1 MLDS technician to maintain equipment and add solution to fog generator.	1 MLDS worker to spray PermaCon 1 radiological control technicians
PPE	Supplied air suits		Supplied Air Suits
Time to enter PermaCon	30 minutes	N/A	30 minutes
Time to apply	19 minutes	12 hours	5 hours
Time to collect smears	27 minutes		27 minutes
Time to leave PermaCon	20 minutes	N/A	20 minutes
Drying/Curing Time	9 hours	over night	24 hours
Time to remove coating	10 minutes		30 minutes
Total volume decontamination chemicals used in demonstration	1 gallon	3 gallons fogging solution	30 gallons Iso-Cyanate 30 gallons resin
Primary waste generated	Contaminated solid waste	None	Contaminated solid waste
Secondary waste generated	(1) 55 gallon drum	None	Plastic sleeving for hose Rags (for cleanup of equipment) Spray gun (contaminated) Disposable PPE
Radiological survey of primary waste stream			Highest survey reading of cured coating as removed from surfaces (as gross contamination) 20,000 dpm/100 cm^2
Airborne contamination	During application - 440 dac.	Before fogging - 440 dac. After fogging - 0.5 dac.	Remained at 0.5 dac.
Demobilization			
Equipment removal/clean-up	70 minutes	75 minutes	120 minutes

SECTION 4
TECHNOLOGY APPLICABILITY AND ALTERNATIVES

Competing Technologies

Competing technologies include other decontamination technologies such as electrochemical, wipe down, etc. The major difference between the foregoing technologies and the fog and strip technology is that the latter allows reduction of airborne contamination to more acceptable levels. This makes the PPE requirements less stringent. In addition, very little waste volume is generated when using the fog and strip technology, especially when the strip is left in place. The electrochemical technology and other technologies where chemicals are used, generate liquid waste, which become a problem for disposal.

Another competing approach is manual wiping and cleaning. The advantage of this approach is its lower cost compared to other technologies. However, the following are disadvantages of manual wipe and clean:

- Increased exposure of personnel to contamination. The use of the fog and strip technology allows D&D personnel to minimize exposure by fast application and removal times. In addition, fewer personnel would need to be involved to decontaminate a large area using the strippable coating versus manual cleaning.
- Potential cross contamination as a result of improper technique.

Technology Applicability

The fog and strip technology is a commercially available technology designed for the decontamination of surfaces, which have transferable (non-fixed) contamination. Although the fog and strip technology was demonstrated at NFS on large, flat surfaces (walls, floors, etc.), the coating is effective in decontaminating components such as gloveboxes, hand tools, casks, reactor headstands, or reactor coolant pumps.

The fog and strip technology can be applied to any confined space where personnel entry is limited by high air-borne contamination levels. Other potential DOE of commercial nuclear applications include the use of the fog and strip decontamination technology to protect clean surfaces so that they will not become contaminated. It can be used to cover clean equipment and scaffolding prior to use in a contaminated area. This coating can also be used to lock down or fix contamination on surfaces for long periods of time.

Patents/Commercialization/Sponsor

Insta-Cote™ is manufactured by MLDS. This product is protected in the United States under patents and trademarks. No permits were required to demonstrate the fog and strip technology at NFS.

SECTION 5
COST

Methodology

The cost analysis evaluates the cost of the fog and strip decontamination technology and compares it with the baseline technology if applied at a DOE Site. This cost analysis considers the mobilization, application, and demobilization costs for each technology.

This analysis presents realistic estimates that represent actual deactivation work at NFS. For consistency amongst ITSRs, the cost estimates use hourly rates and PPE costs for LANL, which can be adjusted for any site considering this technology.

The site demonstration of the baseline technology was based on the strippable coating material being applied to and removed from a 128-ft^2 surface area (approximately 10 % of the total PermaCon area). An estimate for application and removal of the Stripcoat TLC™ for the entire PermaCon was extrapolated based on the time required for this effort.

For the innovative technology, the entire PermaCon was fogged and Insta-Cote™ was then applied. As with the baseline technology, the coating was then stripped from a 128-ft^2 surface area. Some other adjustments of the raw data were made, but only those adjustments that would not distort the fundamental elements of the observed data. Adjustments are described in later portions of the analysis and in Appendix B.

The following cost elements were identified from the Army Corps of Engineers Hazardous, Toxic, and Radioactive Waste Remedial Action Work Breakdown Structure (HTRW RA WBS) and Data Dictionary (Reference 2) as being applicable to the technology demonstration:

- Mobilization Costs include transporting the technology equipment to the demonstration site, preparation of the temporary work area, and a checkout or field test of the equipment
- Decontamination Costs - Includes all direct and indirect activities associated with decontaminating the area, equipment repositioning, and troubleshooting.
- PPE costs are included in this demonstration. For the alternative technology, each participant had two PPE changes per day. For the baseline technology, each participant had three PPE changes for the entire job. In the Appendix B tables, PPE changes were rolled into the D&D cost element.
- Both technologies produce a solid waste. Cost for disposal of waste is based on the prevailing waste disposal rates at LANL. Solid waste is disposed of at a cost of $100 per cubic foot.
- Demobilization includes clean-up of the temporary work area, technology equipment decontamination (or cleanup), and removal of the equipment from the demonstration site.

Key assumptions for the cost estimate are listed below:

- A site will purchase the Stripcoat TLC™ and its application equipment. Site Labor will be utilized for application.
- A site will contract MLDS to provide the fog and strip technology. This cost will be based on the cost quoted by MLDS to perform the decontamination of the PermaCon at NFS. This cost includes time, equipment and material (chemical) costs along with the costs of support personnel. Standard rates for LANL support personnel were used in the estimate.
- No overhead factors were applied to other direct costs.

Other assumptions and details about the cost analysis are presented in Appendix B.

Cost Analysis

Data were collected during the demonstration for each of the cost elements. Time to complete a task associated with the alternative technology was recorded. Labor hours were multiplied by a work group's collective charge rate. As applicable, equipment and material costs were added to the labor cost. Unit costs and waste generation rates were determined based on the surface area that was decontaminated.

For both the innovative and baseline technologies, costs for personnel protective equipment and waste disposal were based on LANL rates. Indirect costs were omitted from the analysis, since overhead rates can vary greatly between contractors. Engineering, quality assurance, administration costs, and taxes were also omitted from the analysis.

Innovative Technology
Crew size for the fog and strip technology varied between two and three MLDS mechanics and a LANL health protection technician. Costs were based on the MLDS contracted cost, broken down by work elements: Mobilization (33%), Stabilization (50%), and Demobilization (17%). Additional costs were estimated for LANL support staff members as required and for final waste disposal.

Approximately 1,288 ft^2 of Insta-Cote™ was applied during the demonstration; however, not all of this was removed, some was left on as a fixative. Since only 128 ft^2 were stripped (removed) during the demonstration, the unit production rate used for the cost analysis was based on a job size of 128 ft^2 and extrapolated to the entire PermaCon.

Baseline Technology
Crew size for the baseline technology was based on recorded data from the demonstration, and LANL labor rates were applied to provide for an equivalent cost comparison. Mobilization cost was based on data collected at NFS, and demobilization cost was extrapolated from a comparable ITSR. Capital equipment cost for the baseline technology was based on the cost of ownership.

The cost of the strippable coating applicator is $5,000 including shipping. Since no information was available to definitively determine the projected time of use per year, the following plausible assumptions were made to calculate the equipment unit rate:

- the expected useful life of the strippable coating equipment package is five years, and
- the equipment is operated eight hours per day, five days per week, for 26 weeks per year (130 days/yr).

In order to amortize the equipment cost for this demonstration, a factor of 0.0015 [1/(5 yr. * 130 days/yr)] was applied to the initial cost.

The costs for application of the Bartlett Stripcoat TLC™ was based on data obtained from application and removal on a 128 ft^2 area of the PermaCon. Only one gallon of Stripcoat TLC™ was used in the entire 128 ft^2 application although the manufacturer's recommended application rate would have required 5 gallons to be applied. The total application time and material quantities were adjusted to account for this operational error and estimates developed for the entire PermaCon. Details are discussed in Appendix B. Extrapolated unit costs were then determined for each technology. On a purely unit cost basis, the baseline technology is less expensive.

Cost Conclusions

The cost estimates provide reasonable costs for implementation of the Fog and Strip technology and the baseline technology at a DOE site. From Appendix B, the estimated cost for the innovative technology is $38,562 or approximately $29.94 per square foot ($338 per square meter). By contrast, the estimated cost of the baseline technology was $30,362 or approximately $23.57 per square foot ($266 per square meter). Therefore, the cost of the innovative technology is only slightly larger than the cost of the baseline technology, although the innovative technology provides better control of airborne contaminates. Figure 3 shows the costing information on a bar chart.

Decontamination tasks with greater or lesser surface areas will have similar mobilization and demobilization costs, although the application time/cost and waste volumes will vary accordingly.

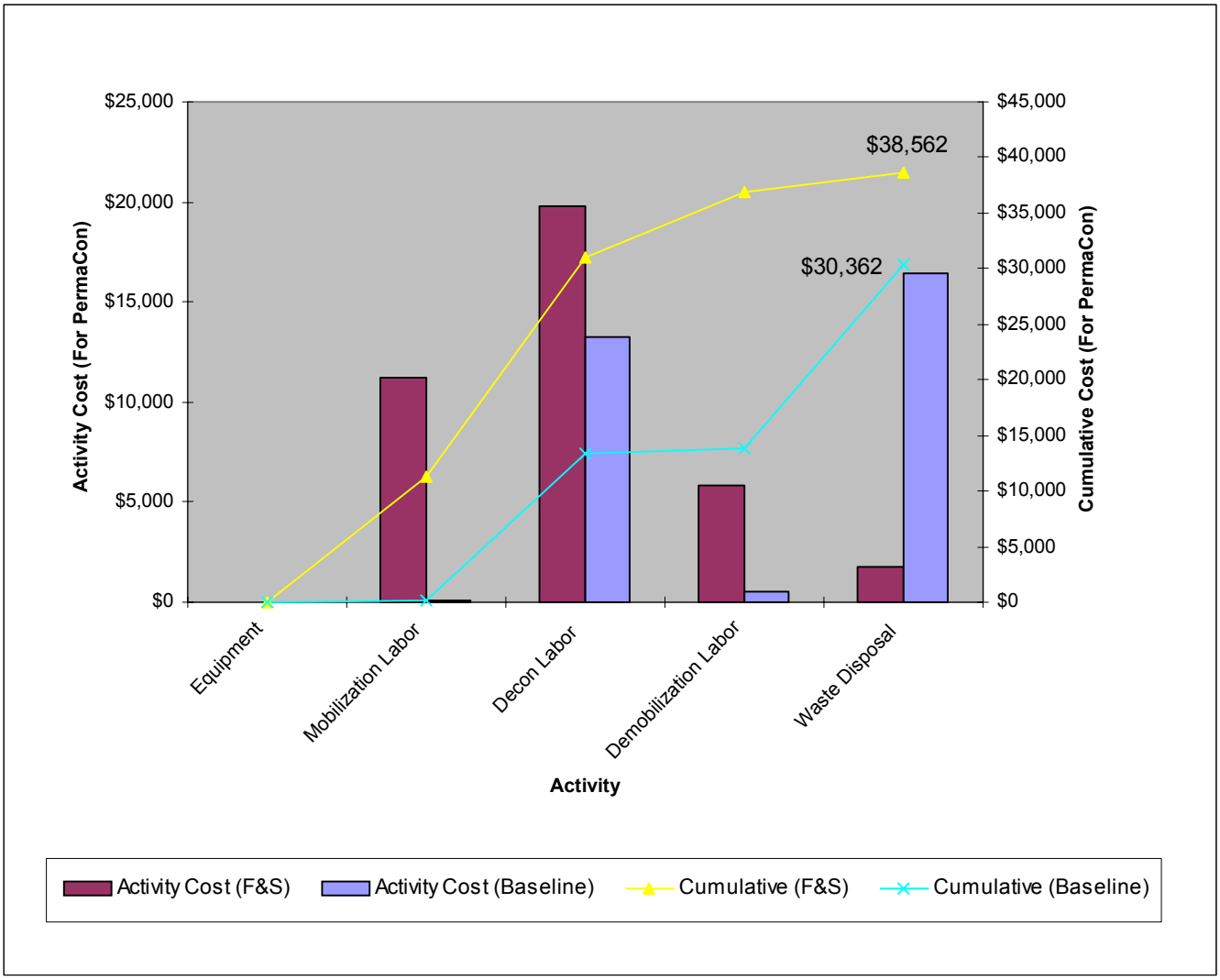

Figure 3 – Costs for Fog and Strip Decontamination vs. Baseline

SECTION 6
REGULATORY AND POLICY ISSUES

Regulatory Considerations

Although there were no site-specific regulatory issues concerning the fog and strip demonstration at NFS, the following general safety and health regulations should be considered in applying the fog and strip technology by spray applicator.

Occupational Safety and Health Administration (OSHA) 29 Code of Federation Regulations (CFR) 1910

1910.94	Ventilation
1910.134	Respiratory Protection
1910.269	Electric Power Generation, Transmission, and Distribution

OSHA 29 CFR 1926

1926.57	Ventilation
1926.103	Respiratory Protection
1926.302	Power-operated Hand Tools

Safety, Risks, Benefits, and Community Reaction

Worker Safety

Certain salient worker safety issues should be mentioned:

Radiation protection worker safety instructions are already in use at the facility apply.

The user of the technology must use contamination control practices when applying coatings.

Normal worker safety precautions and practices prescribed by OSHA for equipment operation (especially compressors) must be followed. Use of proper respiratory protection is needed when spraying formulations that contain iso-cyanates.

Community Safety

It is not anticipated that implementation of the innovative technology would present any adverse impacts to community safety.

SECTION 7

LESSONS LEARNED

Implementation Considerations

Coatings reduce the risk of creating airborne contamination while D&D work—such as cutting, dismantling, and disassembly—is performed; the coatings also enhance interim safe storage.

Technology Limitations and Needs for Future Development

Currently the determination for the end point of the fogging application is based on the judgement of the contractor. It would be desirable for the contractor to develop quantitative criteria that would help to determine how long fogging should continue.

Technology Selection Considerations

The technology is suitable for DOE nuclear facilities or any other sites where radioactive or chemical contamination must be stabilized.

APPENDIX A
REFERENCES

1) IT Corporation, 1999, Test Plan for LANL Fog and Strip Technology Demonstration

2) U.S. Army Corps of Engineers. January 1996. Hazardous, Toxic, and Radioactive Waste Remedial Action Work Breakdown Structure, Prepared for the U.S. Department of Energy (draft)

APPENDIX B
TECHNOLOGY COST COMPARISON

Introduction

The cost-effectiveness computer analysis for the fog and strip decontamination of PermaCon surfaces uses hourly rates for equipment and labor observed in the course of demonstrating the innovative technology and the baseline technology. The observed production rates were extrapolated to the entire PermaCon surface area, which consists of 1,228 square feet. The analysis assumes that the innovative technology work is performed as a vendor-provided service (vendor-owned equipment and personnel)

The selected activities being analyzed are grouped in accordance with the HTRW RA WBS. The HTRW RA WBS, which was developed by an interagency group, was used in this analysis to provide consistency with the established, normal standards.

Some costs are omitted from this analysis to make it easier to understand and to facilitate comparison with costs of other sites. The general and administrative (G&A) markup costs for the site contractor managing the demonstration are omitted from this analysis. Overhead rates for each DOE site vary in magnitude and in the way they are applied. Decision-makers seeking site-specific cost can apply their sites G&A rate to this analysis without having to first back out the rates used at LANL.

The following assumptions were used as the basis for the cost analysis for the innovative technology:

The equipment hourly rates for the site-owned equipment that may be used in support of the innovative equipment (e.g. compressor) uses standard equipment rates established by LANL.

The standard labor rates established by LANL for estimating D&D work are used in this analysis for the portions of the work performed by local crafts.

The analysis uses an 8-hour work day

MOBILIZATION AND PREPARATORY WORK (WBS 33.1.01)

Alternative Technology
Move Fogging Equipment into area near PermaCon and Test Equipment. Set-up for the fogging phase of the demonstration included moving the aerosol generator from the truck, connecting a hose to the PermaCon, turning down ventilation, and heating up the aerosol generator. This required two MLDS technicians, two workers, and two engineers for one hour.

Set-up and test of Insta-Cote™ Application Equipment:
This activity includes connection of application machine to power supply, heat up, sleeving the hose, and testing the spray gun. This required two MLDS technicians for four hours

Baseline Technology
Move Stripcoat TLC™ application equipment into area near PermaCon and Test Equipment. Set-up for the fogging phase of the demonstration included moving the Stripcoat TLC ™ application equipment near the PermaCon from another area and testing the spray gun. This required 4 technicians for 22 minutes.

STABILIZATION (WBS 33.1.17)

Safety Meeting:
For the demonstration, a safety meeting was held each morning following the first day of work. The duration of these meetings varied from 15 to 30 minutes. It is assumed for this analysis that the average safety meeting time is 30 minutes for each of four workers.

Don and Doff PPE:
This cost item includes time for each worker to fully suit up in, and remove, PPE as well as material cost for PPE. Respirator costs are not included. The time spent donning and doffing each day is based on observed times during the demonstration. Material cost for daily PPE for one D&D worker at LANL are shown in the table below.

PPE Cost Per Person	
Equipment	(US $)
Coverall	6.00
Hood	0.84
Gloves (inner)	0.20
Gloves (outer)	1.35
Gloves (liner)	3.76
Rubber Overshoe	12.15
Respirator Cartridge	8.00
Laundry Fee	4.00
Total	36.30

In addition there is a $250 respirator cleaning cost for each respirator, once per month.

Alternative Technology
Fog the PermaCon:
The PermaCon was fogged for a total of 24 hours. Since the aerosol generator can run during non-working hours, it is assumed there are no man-hours spent. The cost of the fog is $77/gallon. During the demonstration, a total of 3 gallons were used. Therefore, the cost per volume of fog solution is $0.093/ft^3 (77 x 3/2484).

Apply Coating:
This activity includes applying the Insta-Cote™ to the PermaCon. This includes 2 MLDS technicians and 2 HP technicians. One MLDS technician enters the PermaCon to apply the Insta-Cote™, while another maintains the application equipment in the truck. During the demonstration, the time required for the MLDS technician to don PPE and enter the PermaCon was 30 minutes. It took 5 hours to spray all PermaCon surfaces. During the demonstration, approximately 940 lbs of Insta-Cote™ was used. The cost of Insta-Cote™ is $10.30/lb, therefore the total cost of Insta-Cote™ used for the demonstration was $9,682. The cost per area is $7.88/ft^2.

Remove Coating:
One MLDS technician and one worker enter the PermaCon to manually strip/peel off the applied coating and package the solid contaminated waste. During the demonstration, 128 ft^2 of the applied Insta-Cote™ was removed in 30 minutes. The removal rate of Insta-Cote™ is therefore, 256 ft^2/hr (128 x 60 / 30).

Baseline Technology
Apply Coating:
This activity includes applying Bartlett Stripcoat TLC™. This includes 2 operators to enter the PermaCon and apply the coating then exit, and 2 radiation technicians for health and radiation monitoring. During the demonstration, the time required for the 2 workers to don PPE and enter the PermaCon was 30 minutes.

In the demonstration, it took 19 minutes to apply approximately 1 gallon of Stripcoat TLC™ to 128 ft^2 of the PermaCon. However, based on the technical data for Stripcoat TLC™, the recommended coverage is 26 ft^2/gallon which would result in approximately 5 gallons for 128 ft^2, or 47 gallons for the entire 1228 ft^2. At an application rate of 19 minutes/gallon, 47 gallons of Stripcoat TLC™ would require 893 minutes or approximately 15 hours to apply. Since entries into the PermaCon are typically limited to approximately 2 hours each, this effort would involve 15 entries (assume 2 per day) with the associated PPE requirements.

The cost of Stripcoat TLC™ is $96/gallon. The cost of Stripcoat TLC™ on an area basis is $3.69/ft^2. Based on these factors, to coat the entire 1228ft^2 PermaCon area would require 15 hours and cost $4,512 for material.

Remove Coating:
One MLDS technician, and 1 worker entered the PermaCon to manually strip/peel off the applied coating and package the solid contaminated waste. During the demonstration, 128 ft^2 of the applied Stripcoat TLC™ was removed in 10 minutes. The Stripcoat TLC™ removal rate is then 768 ft^2/hr (128/10x60). At this rate, 1.6 hours (1228/768) would be required to strip the entire PermaCon.

DEMOBILIZATION (WBS 331.21)

Alternative technology
Move Fogging Equipment from area: Demobilization of the Fogging phase of the fog and strip demonstration includes removing the hose from the PermaCon, disconnecting and moving the aerosol generator to the truck. During the demonstration, two technicians removed the hose from the HEPA filter housing in one hour. Two MLDS technicians disconnected the fogging equipment and returned it to the truck in 15 minutes. Cost associated with decontaminating the gun were not considered.

Move Insta-Cote™ Application Equipment from Area: This required un-sleeving the spray hose and moving return spray gun and hose to the truck. This took two MLDS technicians two hours.

Baseline Technology
Move Stripcoat TLC™ application from Area: This required un-sleeving the spray hose and moving return spray gun and hose to the truck. This took two MLDS technicians two hours.

WASTE DISPOSAL (WBS 331.18)

Alternative Technology
Approximately 2½ drums of solid waste were produced during the fog and strip phase of the demonstration This waste includes the removed stripping, PPE, and plastic hose sleeve.

Baseline Technology
Approximately ½ drum of solid waste was produced during the Stripcoat TLC™ phase of the demonstration. Projecting this waste rate for 47 gallons of Stripcoat TLC™ results in 23.5 drums of waste. This waste includes the removed stripping, PPE, and plastic hose sleeve.

The details of the cost analysis for the alternative and baseline technologies are summarized in Tables B-1 and B-2.

Cost Estimate Summary

The cost analysis details are summarized in Tables B-1 and B-2 which break out each member of the crew, each labor rate, and each piece of equipment us

Table B-1: Baseline Implementation Cost

TITLE	LABOR	LABOR QUANTITY	EQUIPMENT	UNIT OF MEASURE	UNIT COST	QUANTITY	SUBTOTALS
Mobilization and Preparatory Work (WBS 33.1.01)							**$120.64**
Equipment							*$7.50*
			Coating Applicator	Each	$5,000.00	0.0015	$7.50
Mobilization							*$113.14*
	Technical Staff Member	4		Hour	$48.00	0.4	$76.80
	Supervisor	1		Hour	$90.86	0.4	$36.34
Stabilization (WBS 33.1.17)							**$13,257.30**
Safety Meeting and Application							*$6,636.50*
	Technical Staff Member	2	Includes 3 Safety Mtgs	Hour	$48.00	15.0	$1,440.00
		14	Don PPE and enter work zone	Hour	$48.00	0.5	$336.00
		14	Dof PPE and exit work zone	Hour	$48.00	0.3	$201.60
	Radiation Technician	2	Includes 3 Safety Mtgs	Hour	$80.00	15.0	$2,400.00
		14	Don PPE and enter work zone	Hour	$80.00	0.5	$560.00
		14	Dof PPE and exit work zone	Hour	$80.00	0.3	$336.00
	Supervisor	1	Includes 3 Safety Mtgs	Hour	$90.86	15.0	$1,362.90
Materials							*$4,512.00*
			Bartlett Stripcoat TLC	Gallons	$96.00	47.0	$4,512.00
PPE							*$2,108.80*
			Tyvek Coverall	Ea.	$6.00	28	$168.00
			Tyvek Hood	Ea.	$0.84	28	$23.52
			Latex Overboots	Pair	$3.30	28	$92.40
			PVC Overboots	Pair	$12.15	28	$340.20
			Glove Liners	Pair	$3.76	28	$105.28
			Gloves N-DCR	Pair	$0.20	28	$5.60
			Gloves Nitril/Latex	Pair	$1.35	28	$37.80
			Respirator Cartridge	Set	$8.00	28	$224.00
			Respirator Cleaning	Ea.	$250.00	4	$1,000.00
			PPE Laundry Service Fee	Unit	$4.00	28	$112.00
Demobilization (WBS 33.1.21							**$533.72**
	Technical Staff Member	2		Hour	$48.00	2	$192.00
	Radiation Technician	1		Hour	$80.00	2	$160.00
	Supervisor	1		Hour	$90.86	2	$181.72
Waste Generation (WBS 33.1.18)							**$16,450.00**
			Drums (~7ft^3 each)	Each	$700.00	23.5	$16,450.00
TOTAL							**$30,361.66**

Table B-2: Innovative Technology Implementation Cost

TITLE	LABOR	LABOR QUANTITY	EQUIPMENT	UNIT OF MEASURE	UNIT COST	QUANTITY	SUBTOTALS
Mobilization and Preparatory Work (WBS 33.1.01)							**$11,219.00**
Mobilization and Set-up Equipment							$11,219.00
	MLDS Contract	1	Included	LS	$11,027.00	1	$11,027.00
	Technical Staff Members	2		Hour	$48.00	1	$96.00
	Engineer	2		Hour	$48.00	1	$96.00
Stabilization (WBS 33.1.17)							**$19,768.60**
Safety Meeting and Application							*$17,507.00*
	MLDS Contract	1	Materials Included	LS	$16,707.00	1	$16,707.00
	Health Physicist	2		Hour	$80.00	5.0	$800.00
Remove Insta-Cote							*$128.00*
	Technical Staff Members	1	Includes Safety Mtgs	Hour	$48.00	1	$48.00
	Health Physicist	1		Hour	$80.00	1	$80.00
PPE cost							*$2,133.60*
			Tyvek Coverall	Ea.	$6.00	16	$96.00
			Tyvek Hood	Ea.	$0.84	16	$13.44
			Latex Overboots	Pair	$3.30	16	$52.80
			PVC Overboots	Pair	$12.15	16	$194.40
			Glove Liners	Pair	$3.76	16	$60.16
			Gloves (outer)	Pair	$1.35	16	$21.60
			Gloves (inner)	Pair	$0.20	16	$3.20
			Respirator Cartridge	Set	$8.00	16	$128.00
			Respirator Cleaning 1/month	Ea.	$250.00	6	$1,500.00
			PPE Laundry Service Fee	Unit	$4.00	16	$64.00
Demobilization (WBS 33.1.21							**$5,824.00**
Demobilization							*$5,824.00*
	MLDS Contract	1		LS	$5,680.00	1	$5,680.00
	Technical Staff Members	2	Includes Safety Mtgs	Hour	$48.00	1.5	$144.00
Waste Generation (WBS 33.1.18)							**$1,750.00**
			Drums (~7ft^3 each)	Each	$700.00	2.5	$1,750.00
TOTAL							**$38,561.60**

APPENDIX C
ACRONYMS AND ABBREVIATIONS

CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
D&D	decontamination and decommissioning
HTRW RA WBS	Hazardous, Toxic, and Radioactive Waste Remedial Action Work Breakdown Structure
ITSR	Innovative Technology Summary Report
LANL	Los Alamos National Laboratory
LSDDP	Large Scale Demonstration and Deployment Project
MLDS	Master-Lee Decontamination Services
NFS	Nuclear Fuel Services
OSHA	Occupational Safety and Health Administration
OST	Office of Science and Technology
PPE	Personal Protective Equipment
TMS	Technology Management System